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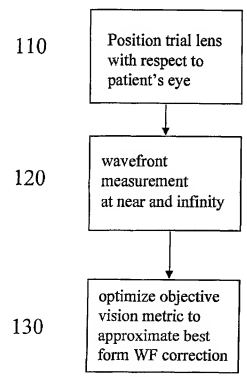
(54) Title: PRESBYOPIC VISION IMPROVEMENT



(57) Abstract: A method of designing a contact lens or other correction for providing presbyopia correction to a patient relies on wavefront aberration measurement data for providing a best form correction. Preferably the correction is in the form of a multifocal translating style alternating vision contact lens or a simultaneous vision style correcting lens. A method for designing a correction for improving a person's vision is directed to correcting higher order aberrations in such a manner that a residual amount of the higher-order rotationally symmetric aberration is greater than a residual amount of the higher-order rotationally asymmetric aberration after the correction. A design method according to the invention is directed to correcting asymmetric higher order aberrations induced by decentering of a multifocal contact lens that has residual spherical aberration which provides increased depth of field.

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Declaration under Rule 4.17:

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PRESBYOPIC VISION IMPROVEMENT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to the field of presbyopic vision correction and, more particularly, to the use of a wavefront sensor for the measurement, design, fit and dispensing of a vision altering optic or vision correcting procedure to improve presbyopic correction and visual performance.

Description of Related Art

A form of age-dependent vision deterioration experienced sooner or later by 100% of the population is called presbyopia, i.e., the inability to accommodate or focus on objects close to the eye. Two well-known methods for dealing with presbyopia include alternating vision style correction and simultaneous vision style correction.

In an example of an alternating vision style correction, two (or more/multi-focal) distinct optical regions of a translating style contact lens are designed, one optimized for distance vision and the other for near vision. Typically in an alternating vision bifocal contact lens, the lens will translate on the eye such that the pupil is mostly covered by the distance viewing portion of the lens; however, when eye gaze points downward, such as when a person reads a newspaper, the lens translates on the eye such that the pupil is mostly covered by the near distance viewing portion of the lens.

Alternatively, simultaneous style vision correction has been provided through, e.g., contact lenses, IOLs, refractive surgery, etc. In this style of correction, all light from the object goes through the pupil at the same time, preferably with a 50/50 split between near distance and far distance object light. Any one of a number of refractive or

diffractive bifocal or multifocal designs are used to focus light from objects ranging in the field of view from far distance (greater than about 7m) to near distance (as close as about .25m but typically about 40 cm) on the retina at the same time.

As a person gets older, not only do they lose the ability to accommodate, they also experience an increase in what are known as higher order wavefront aberrations. These include, but are not limited to, spherical aberration, coma, irregular astigmatisms (e.g. triangular astigmatism or trefoil), and others. The aberrations corrected by spectacles or single vision contact lenses are limited to defocus and astigmatism which are generally referred to as lower-order aberrations. An increase in spherical aberration brought about, for example, by advancing age, will decrease nighttime vision quality. This may manifest itself as halos or glare around headlights or other light sources. Unfortunately, for the presbyope hoping for better near distance vision with a translating-style contact lens, the correction of the spherical aberration for improved far distance, night time vision results in a decrease in near vision depth of field; i.e., the amount an object's distance can be shifted before the retinal image of the object has too much blur.

There are also vision tradeoffs for the multifocal, simultaneous style correction lens wearer. Although there are claims of excellent clinical success with a number of simultaneous vision bifocal and multifocal designs, actual published success rates with refractive and diffractive contact lenses for presbyopic correction range only from about 20% to 50% of the general presbyopic population. One of the apparent limiting factors of all current simultaneous style vision correction for presbyopia is lens misalignment; i.e., the lack of control of the centration of the lens relative to the optical axis of the patient. Unfortunately, the induced aberrations caused by the optical misalignment of

the eye with the simultaneous vision correction lens reduces visual performance to the point that vision quality is unacceptable to the patient at any viewing distance.

One approach to alleviating vision performance problems is, presumably, to eliminate all optical aberrations in the eye. In the first instance, this solution may not be technically feasible, although correction of wavefront errors *via* customized refractive surgical techniques and/or customized contact lenses, inlays, onlays, and IOLs, for example, is becoming better understood each day. Moreover, the elimination of all optical aberrations in the eye may not be desirable. For example, reducing spherical aberration will adversely affect depth of field, as discussed above, thus some residual spherical aberration may be desirable for optimum vision quality.

Accordingly, there is a need for vision correcting methods and devices that address the aforementioned problems. In particular, methods and apparatus are needed for providing multifocal lens correction of presbyopia with improvement, or at least no degradation, of other aspects of vision quality.

SUMMARY OF THE INVENTION

The invention in general relates to methods and devices for optimizing presbyopic vision correction, preferably with a contact lens, but not limited as such and including, as appropriate, IOLs, inlays, onlays, or refractive surgery. A predominate theme of all of the embodiments of the invention is the use of a wavefront sensor in the design and fitting of alternating vision and simultaneous vision style corrective lenses, or in refractive surgery, and in balancing various aberrations to achieve the best objective vision metric possible.

An embodiment of the invention relates to a method for designing either a customized, multifocal, alternating style translating contact lens or a simultaneous vision style correcting lens, and the providing such a lens to a presbyopic patient. The method comprises the steps of positioning, with respect to a patient's eye, a multifocal trial lens that is representative of an actual lens to be provided to the patient, wherein the trial lens has a correction of approximately a distance defocus power of the patient's eye; making a first wavefront aberration measurement of the patient's eye with the trial lens in position, at a viewing distance equivalent to optical infinity; making a second wavefront aberration measurement of the patient's eye with the trial lens in position, at an artificial optical near point viewing distance; and using the first and second wavefront aberration measurements to approximate a best form wavefront correction to be applied to the contact lens, whereby the patient's presbyopic vision is improved. It will be clear to a person skilled in the art that the step of positioning the lens with respect to the patient's eye has alternative aspects. For example, if the lens to be provided is a translating style, alternating vision type contact lens, the position of the representative trial lens will be on the patient's eye. In a different aspect where the lens to be provided is a simultaneous vision style correcting lens element, the lens element can be a contact lens that will be positioned on the patient's eye; however, if the simultaneous vision style correcting lens element is an IOL, the representative trial lens will be suitably positioned in an optical path of the wavefront sensor device used to make the wavefront aberration measurement. The wavefront aberration measurements are preferably made along a central axis of the trial lens. The best form wavefront correction will provide an optimum retinal image metric, preferably a Point Spread Function (PSF) having a single intensity peak or a Strehl ratio having as large a value as possible, for example. Other retinal image metrics

known to those skilled in the art can also be used. The near point viewing distance wavefront measurement should be in the range of about 30-50cm and will typically be approximately 40cm. For the case of a translating style, alternating vision type correcting contact lens, the near distance measurement is obtained by inducing a down gaze of the patient's eye to produce the trial lens translation similar to that of an actual translating multifocal contact lens when worn by the patient. In an aspect of this embodiment, use of the wavefront sensor in designing and fitting a translating style multifocal contact lens will allow the practitioner to monitor the retinal image metric for optimum presbyopic vision while adjusting, e.g., residual spherical aberration in the lens that will result in the best overall vision for the patient while providing an acceptable depth of field to the patient.

In another aspect of the embodiment for designing and providing a simultaneous vision type correcting lens, use of the wavefront sensor facilitates the optimum lateral, vertical, and rotational placement of the lens to optimize the retinal image metric. This can be accomplished, e.g., by adjusting the position of the patient's head and, therefore, the patient's optical axis with respect to the measurement axis of the wavefront sensor or, alternatively, utilizing a feedback loop in the wavefront sensor to determine the optimum location in the lens for aberration correction. In a related aspect, wherein a patient has had photorefractive surgery such as LASIK, for example, a retreatment may be performed to correct for misalignment or decentration of the original ablation treatment that resulted in vision degrading higher-order aberrations. Upon retreatment, the surgeon may choose not to fully eliminate the residual spherical aberration.

In another embodiment of the invention, a method for designing a lens or other correction (e.g., réfractive surgery correction) to improve a patient's vision quality that is

degraded by both rotationally symmetric and rotationally asymmetric aberrations involves designing the lens or the correction such that a residual amount of the rotationally symmetric aberrations are greater in magnitude than a residual amount of rotationally asymmetric aberrations, e.g., coma. Once again, exemplary metrics for evaluating the patient's visual quality include, but are not limited to, the PSF and the Strehl ratio. The amount of residual or uncorrected rotationally symmetric aberrations will vary in each patient, and guidance will be provided by the aforementioned metrics. Preferably, the distribution of light in the PSF will not contain multiple peaks.

In another embodiment, a method for designing a lens or a correction for enhancing the near vision performance of a presbyopic patient includes a design that eliminates less than the total amount of the spherical aberration in the person's visual optical system so as to increase the person's depth of field. Aspects of this embodiment include ocular corrections that apply to vision altering optics such as contact lenses, IOLs, inlays, onlays, and the like, to the cornea through laser ablation and other refractive surgical techniques, and to other components of the eye.

These and other objects and advantages of the invention will be further apparent in consideration of the drawings and the detailed description of the preferred embodiments, and in view of the appended claims defining the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the present invention and, together with the description, serve to explain the objects, advantages and principles of the invention. In the drawings,

Figure 1 is a flow chart diagram illustrating a preferred embodiment of the invention; and

Figure 2 is a flow chart diagram illustrating another preferred embodiment according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An embodiment of the invention describes, with reference to Figure 1, a method 100 for designing either a customized multi-focal, translating style, alternating vision contact lens, or, a simultaneous style vision-correcting lens, and providing the lens to a patient. In step 110, a multi-focal trial lens is first positioned appropriately with respect to the patient's eye. The trial lens is representative of the customized lens ultimately to be provided to the patient, and should provide correction for the defocus aberration experienced by the patient. In an aspect of the embodiment where the lens ultimately to be provided to the patient is a translating style, alternating vision type multifocal contact lens, the appropriate positioning of the trial lens will be on the patient's eye in the form of a trial contact lens. In an alternative aspect of the embodiment where the lens to be provided to the patient is a correcting lens element not worn on the surface of the cornea such as an IOL or inlay providing simultaneous style presbyopic vision improvement to the patient, the appropriate positioning of the trial lens will be in the optical measurement path of a wavefront sensor to simulate the optical effect as if the lens element was *in-situ*. Wavefront aberration measurements are then made at step 120 through the trial lens in such as manner that the patient is imaging at optical infinity and at an optical near point distance, preferably 30 – 50 cm from the patient's eye and, more preferably, approximately 40 cm from the patient's eye. A down gaze of the patient's eye can be

induced by using a front surface mirror in the measurement apparatus or by any of a number of known means, for making the near vision measurement. In step 130, the near distance and infinite distance aberration measurements are then used to approximate a best form wavefront correction to a customized lens ultimately to be provided to the patient. The best form wavefront correction is preferably determined by optimizing a retinal image metric such as, for example, a point-spread function (PSF) or a Strehl ratio. Simply, the PSF corresponds to the energy distribution in the image of a point source of light object. An optimized PSF, for instance, would have only a single intensity peak representing the light distribution of the imaged spot. The Strehl ratio can be defined as the ratio of the area under the point spread function of the actual optical system wavefront (i.e., aberrated wavefront) to that for the diffraction limited case (i.e., no wavefront aberration in the optical system). Thus a Strehl ratio of 1.0 would describe a substantially perfect optical imaging system. Further information may be obtained from the text by Warren J. Smith entitled *Modern Optical Engineering*, McGraw Hill, Inc. (1966), incorporated herein by reference.

Generally speaking, as people age their vision deteriorates. Older individuals often report poor nighttime vision. There is also a known correlation between increases in higher order aberrations and increasing age. One conclusion that can be drawn from this evidence is that poorer night vision in older individuals is due to an increase in higher order aberrations naturally experienced by older individuals. Presbyopia is an additional age-related visual deterioration. Although correcting spherical aberration tends to improve nighttime vision problems, it is well known that reducing spherical aberration reduces a person's depth of field. Thus, a presbyopic bifocal wearer may need to choose between better night vision and reduced depth of field for near distance

viewing, or vice-versa. Advantageously, the inventors have recognized that in many cases a person's corrected eyesight may be better when there is some residual spherical aberration after correction. This will provide the added benefit of maintaining or increasing a depth of field for the presbyopic lens wearer. Accordingly, an aspect of the present embodiment of the invention is directed to a correction design process that involves providing a known amount of residual spherical aberration in order to improve visual quality and increase or at least maintain depth of field. Preferably, in the presence of rotationally symmetric higher order aberrations (e.g., spherical aberration) and rotationally asymmetric higher order aberrations (coma, higher order astigmatism), a method of for improving a person's vision involves providing a correction design having a residual amount of rotationally symmetric higher order aberrations that exceed the residual amount of rotationally asymmetric higher order aberrations. This is illustrated with respect to Example 1 below. This may be accomplished preferably through the design of a contact lens or an IOL, or alternatively, in an inlay, onlay, or refractive surgery procedure.

Example 1

This example illustrates the concept that under the ability to manipulate the spherical aberration of an ocular correction, due to the ability to only change rotationally symmetric surfaces or parameters such as, e.g., a contact lens, an IOL, or a broad beam laser, it is more beneficial not to correct all of the spherical aberration when there are significant amounts of non-rotationally symmetric aberrations (e.g., coma, trefoil) present. Patient X had refractive surgery. Her measured post-operative Zernike

coefficient values measured with a Zywave® (Bausch & Lomb, Rochester, N.Y.) wavefront sensor were:

Z7 Coma	0.068		Z15 (Secondary Coma)	-0.183
Z8 Coma	-0.540		Z16 (Secondary Coma)	-0.071
Z9 (Trefoil)	0.103		Z17 (Secondary Coma)	0.021
Z10 (Spherical)	-0.371		Z18 (Secondary Coma)	0.018
Z11 (Spherical)	-0.782		Z19 (Secondary Coma)	0.010
Z12 (Spherical)	-0.308		Z20 (Secondary Coma	-0.026
Z13 (Spherical)	-0.135		Z21 (Secondary Spherical)	0.023
Z14 (Spherical)	-0.007			

One can see that there is significant coma and triangular astigmatism. In Table I, below, the left-most value is the multiplication factor of the Zernike coefficient Z11 that represents the majority of the measured spherical aberration. Looking at the various values of the corrected spherical aberration, it is seen that correcting all of the spherical aberration is actually deleterious to the retinal image quality as measured by the Strehl ratio. The highest Strehl ration is obtained when 25% of Z11 remains. In fact, leaving 50% of the Z11 spherical aberration results in a similar retinal image quality to correcting all of the spherical aberration as defined by the Strehl ratio.

Residual Z11	Strehl Ratio	RMS	Peak-Valley (waves)
0.00 Z11	0.023	0.77	8.34
0.25 Z11	0.036	0.79	8.34
0.50 Z11	0.024	0.87	8.35
0.75 Z11	0.016	0.96	8.68
1.00 Z11	0.007	1.099	9.55

Table I

The optimum amount of corrected spherical aberration will vary in each eye, and may be guided by the Strehl ratio, i.e., the distribution of light within the PSF such that there are not multiple peaks, or by other appropriate retinal image quality metrics well known in the art. The remaining residual spherical aberration will have the additional benefit of

enhancing the near visual performance for presbyopic patients by extending the depth of field for the patient.

It is assumed that one of the major limiting factors of all current simultaneous vision methods for correcting presbyopia is the failure to control the centration of these designs relative to the optical axis of the patient, and that the induced aberrations caused by the optical misalignment of the eye with simultaneous correction reduces the visual performance of the patient being corrected to the point that their visual quality is unacceptable to them at near or far viewing distances. There is speculation that the actual published success rates with refractive and diffractive contact lenses range from 20% to 50% of the general presbyopic population due to the centration issue. This problem is easily exasperated when the lens purposely contains residual spherical aberration as discussed above. Recognition of the centration problem gives rise to another embodiment of the invention described with reference to Figure 2. In this embodiment 200, a wavefront sensor is used not only to measure the patient's higher order aberrations but also to monitor the fitting of a lens element subject to decentration in the person's optical system. With respect to a simultaneous style bifocal contact lens, for example, at step 210 both near distance and far distance higher order aberration measurements are made with a trial lens appropriately positioned on the patient's eye. The optimum lateral, vertical, and/or rotational placement of the simultaneous style lens is then determined at 220 to optimize a retinal image metric. The lens ultimately to be provided to the patient can then be customized in terms of location of aberration correction on the lens and/or for the proper placement of the lens on the patient's eye. In one aspect of this embodiment, the proper measurement coordinates can be explored by displacing the patient's eye relative to the measurement axis of the wavefront sensor *via*

an adjustable chin mount or other appropriate means, or alternatively, by utilizing a feedback loop in the wavefront sensor to determine the optimum placement of the lens on or in the patient's eye. A wavefront sensor equipped with a deformable mirror, for example, as described in Williams U. S. patent 5,777,719 illustrates the basic technology for making such measurements. In an associated aspect of this embodiment shown in step 230, a trial lens having a known amount of spherical aberration is positioned with respect to the patient's eye. Decentering of the lens having spherical aberration induces coma. A customized lens corrected for this induced coma can be designed at 240 by monitoring the wavefront aberrations based on the trial lens. It will be appreciated that the lens itself need not be decentered on the patient's eye or with respect to the patient's optical axis as the decentering, which creates spherical aberration, is equivalent to a properly positioned lens on the patient's eye with residual spherical aberration in the lens. Alternatively, this result may also be accomplished in a refractive surgery retreatment procedure where less than the entire residual spherical aberration is corrected.

Notwithstanding the preferred embodiments specifically illustrated and described herein, it will be appreciated that various modifications and variations of the instant invention are possible in light of the description set forth above and the appended claims, without departing from the spirit and scope of the invention. .

We claim:

1. A method for designing either of a customized multifocal translating style alternating vision contact lens or a simultaneous vision style correcting lens to a patient, comprising the steps of:

positioning a multifocal trial lens with respect to the patient's eye that is representative of the lens to be provided, having a correction of approximately a distance defocus power of the patient's eye;

making a first wavefront aberration measurement of the patient's eye with the positioned trial lens at a viewing distance of optical infinity;

making a second wavefront aberration measurement of the patient's eye with the trial lens in position, at an artificial optical near point viewing distance; and;

using the first and second wavefront aberration measurements to approximate a best form wavefront correction to be applied to the contact lens.

2. The method of claim 1, wherein the best form wavefront correction provides an optimum retinal image metric.

3. The method of claim 1, wherein the first and second wavefront measurements are made along a central axis of the trial lens.

4. The method of claim 1, wherein the second wavefront measurement optical near point distance is between about 30 – 50 cm from the patient's eye.

5. The method of claim 4, wherein the distance is about 40 cm.

6. The method of claim 1, wherein making the second wavefront measurement comprises inducing a translation of the trial lens that is representative of a real use translation of a translating style lens.

7. The method of claim 6, comprising using a front surface mirror to induce the down gaze.

8. The method of claim 1, further comprising making the lens.

9. The method of claim 8, further comprising providing a known amount of residual spherical aberration in the lens that is compensatory for a decreased depth of field associated with decreased spherical aberration.

10. The method of claim 8, comprising providing one of a translating style, alternating vision contact lens, a simultaneous vision style contact lens, and a simultaneous vision style IOL, to the patient.

11. The method of claim 1, wherein positioning the trial lens comprises at least one of fitting a representative translating style, alternating vision contact lens on the patient's eye, fitting a representative simultaneous vision contact lens on the patient's eye, and positioning a representative simultaneous vision IOL in an optical path in a wavefront sensing instrument used to measure the wavefront aberration.

12. The method of claim 1, wherein making the first and second wavefront measurements for a simultaneous style correcting lens comprises determining the optimum lateral, vertical, and rotational placement of the simultaneous style lens to optimize a retinal image metric.

13. The method of claim 12, comprising using a feedback loop with the wavefront sensor to determine the optimum placement of the lens on or in the patient's eye.

14. The method of claim 12, comprising displacing the location of the patient's eye with respect to the measurement axis of the wavefront sensor.

15. The method of claim 1, wherein the step of positioning the trial lens comprises positioning a trial lens having a known amount of spherical aberration to induce a coma aberration in the lens; and correcting for the coma in the best form wavefront applied to the contact lens.

16. A method for designing a correction for improving a person's vision that is deteriorated by optical aberrations including higher-order rotationally symmetric and rotationally asymmetric aberrations, comprising the steps of:

designing a correction for the higher-order rotationally symmetric aberration; and

designing a correction for the higher-order rotationally asymmetric aberration,

wherein a residual amount of the higher-order rotationally symmetric aberration is greater than a residual amount of the higher-order rotationally asymmetric aberration after the correction.

17. The method of claim 16, further comprising evaluating the person's corrected vision by an objective retinal image metric including at least one of a PSF and a Strehl ratio.

18. The method of claim 17, comprising designing the aberration correction such that the PSF has substantially a single peak distribution of light.

19. In a method for designing a correction for improving a person's vision wherein only a rotationally symmetric surface is available upon which to impart an aberration correction, the improvement comprising providing only a partial correction of a total amount of a rotationally symmetric aberration in the presence of an amount of a non-rotationally symmetric aberration.

20. The method of claim 19, wherein the amount of the corrected rotationally symmetric aberration is guided by a retinal image metric.

21. A method for designing a correction for improving a person's vision, comprising using a wavefront sensor output to approximate a best form wavefront correction to be applied to a multi-focal correction so as to provide an optimum retinal image for a presbyopic condition.

22. The method of claim 21, further comprising:

a) providing a trial lens representative of a multi-focal design of the vision altering optic to be tested/dispensed having approximately a correct distance defocus power for the person's eye;

b) measuring a wavefront aberration of the person's eye with the trial lens in-situ, along a central axis of the lens; and

c) using the wavefront aberration measurement to identify at least one of a centration of the optic and an aberration correction area on the surface of the optic.

23. The method of claim 22, wherein the step of measuring the wavefront aberration comprises performing the measurement at optical infinity and at an optical near point distance.

24. The method of claim 23, wherein performing the measurement at the optical near point distance comprises making the measurement at an equivalent distance between about 30-50cm from the person's eye.

25. The method of claim 23, wherein performing the measurement at the optical near point distance comprises making the measurement at an equivalent distance of about 40cm from the person's eye.

26. The method of claim 23, wherein performing the measurement at the optical near point comprises inducing a downgaze to produce a trial lens translation representative of an actual alternating vision style lens translation.

27. The method of 26, wherein a front surface mirror is utilized to induce the downgaze.

28. The method of claim 21, wherein the correction is a multi-focal vision altering optic in the form of an alternating vision, translating style contact lens.

29. The method of 21, wherein the correction is a multi-focal vision altering optic in the form of a simultaneous style correcting lens element.

30. The method of claim 29, wherein the measuring step further comprises decentering the in-situ lens in a measurement path of the wavefront sensor to a final position that produces an optimized wavefront sensor output; and

providing an aberration correction to the lens in a region of the lens corresponding to the final position.

31. The method of claim 30, wherein providing said aberration correction comprises eliminating less than a total amount of spherical aberration from the lens such that a residual spherical aberration amount is greater than a remaining rotationally asymmetric aberration amount.

32. The method of 29, wherein the stop of providing a trial lens comprises providing a trial lens having an amount of spherical aberration;

further wherein the measuring step comprises measuring an amount of coma aberration; and

further comprising providing a wavefront aberration correction for the coma.

33. The method of claim 30, wherein the final position is determined by a feedback loop in the wavefront sensor to produce an optimum lateral, vertical, and rotational placement of the lens.

34. The method of claim 21, wherein the correction is a refractive surgery retreatment in which less than an entire residual spherical aberration is corrected.

35. A contact lens made according to the method of claim 21.

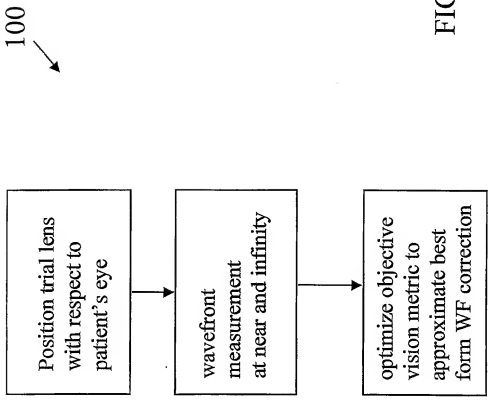
100
110
Position trial lens with respect to patient's eye
120
wavefront measurement at near and infinity
130
optimize objective vision metric to approximate best form WF correction

FIG. 1

200
210
Fit trial lens; monitor WF at near and infinity; optimize metric
220
monitor WF a function of lens decentration
230
monitor coma in relation to spherical aberration
240
design coma correction

FIG. 2

INTERNATIONAL SEARCH REPORT

PCT/US 02/33534

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B3/103

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B G02C A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 777 719 A (LIANG JUNZHONG ET AL) 7 July 1998 (1998-07-07) cited in the application column 5, line 50 -column 6, line 41	16-20
A	WO 01 28477 A (HOHLA KRISTIAN ;TECHNOLAS GMBH OPHTHALMOLOGISC (DE); YOUSSEFI GERH) 26 April 2001 (2001-04-26) page 2, paragraph 2 -page 3, line 3	16-20
A	US 6 086 204 A (MAGNANTE PETER C) 11 July 2000 (2000-07-11) column 2, line 51 -column 3, line 35 column 7, line 50 -column 5, line 33	16-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 January 2003	15/01/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax. (+31-70) 340-3016	Manschot, J

Form PCT/ISA/210 (second sheet) (July 1992)

International application No.
PCT/US 02/33534

INTERNATIONAL SEARCH REPORT

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 1-15, 21-34
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Diagnostic method practised on the human or animal body in that wavefrontaberration measurements on the eye are performed in order to establish the vision correction for designing a contact lens

2. [X] Claims Nos.: 35
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 35

Apparatus Claim 35 refers to method claim 21. Claim 21, however, relates to designing a custumized correction with patient specific features. A correction (lens) made according to this method differs from patient to patient and is therefore, dependent from its use. Consequently, such a lens has no clear distinctive and limiting apparatus features and does not meet Article 6 PCT accordingly.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

PCT/US 02/33534

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